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14. ABSTRACT
The objective of this project is to fully document the effects of acoustic impulses on the middle ear and on middle-ear muscle contractions (MEMC). This project will provide critical information on the middle ear musculature states during warned and unwarned exposures to acoustic impulses. This information necessary in the development of new (or revising existing) damage risk criteria and health hazard assessment methods for exposure to high-level acoustic impulses such as experienced by users of military and civilian law enforcement weapon systems, civilian recreational hunting and shooting, and industrial high-level impulsive noises (impacts and impulses).

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Introduction:

The objective of this project is to fully document the effects of acoustic impulses on the middle ear and on middle-ear muscle contractions (MEMC). This project will provide critical information on the middle ear musculature states during warned and unwarned exposures to acoustic impulses. This information is necessary for the development of new (or revision of existing) damage risk criteria and health hazard assessment methods for exposure to high-level acoustic impulses such as experienced by users of military and civilian law enforcement weapon systems, civilian recreational hunting and shooting, and industrial high-level impulsive noises (impacts and impulses).

Keywords:

Noise exposure; hearing loss, noise-induced; impulsive noise; reflex; conditioned response; middle ear; damage-risk criteria; health hazard evaluation

Accomplishments:

What were the major goals of the project?
The major goals of the project as stated in the approved SOW are:

1. Determine the prevalence of acoustic reflexes among young people with H-1 hearing status as per Army Regulation 40-501, Table 7-1.
2. Determine whether reflexive MEMC are pervasive for multiple acoustic and non-acoustic stimuli.
3. Determine whether conditioned MEMC are pervasive, in either laboratory or field settings, and if so, identify differences between reflexive and conditioned MEMC.

What was accomplished under these goals?

1. Determine the prevalence of acoustic reflexes among young people with H-1 hearing status as per Army Regulation 40-501, Table 7-1.

Major activities
The majority of the work associated with this task was completed during the previous project period, and dissemination is underway. We have disseminated the results from task 1 at the Fall 2015 meeting of the Acoustical Society of America (ASA), 2016 National Hearing Conservation Association (NHCA) annual meeting, Fall 2016 Military Health Science Research Symposium (MHSRS), 2016 Office of Naval Research Noise Induced Hearing Loss (ONR NIHL) Review, and the manuscript draft has been submitted for peer-review to the International Journal of Audiology.

Specific objectives
The first specific objective involved the development of a MEMC detection algorithm for use with the National Health and Nutrition Examination Survey (NHANES) impedance traces. The second specific objective was to determine the prevalence of MEMC, conditioned on demographic, middle ear status, and hearing sensitivity factors and disseminate those findings. Both specific objectives have been completed and the results disseminated.

Significant results
Results have been updated from the previous annual report. The prevalence of reflexive MEMC to acoustic stimuli was reasonably high (72 % met both methods, 95 % confidence interval [70, 74]) among listeners with H-1 hearing status. However, the probabilities of reflexive MEMC were not uniform across audiometric configurations that fit within the limits of the H-1 hearing status. Audiometric configurations fitting within the H-1 hearing status are shown in Figure 1. Acoustic reflex presence within each recording was estimated using two techniques, represented in Figure 2. The estimated prevalence is shown in table 1, and the corresponding prevalence estimates (and 95 % confidence intervals) for the H-1 audiometric status are shown in Figure 3.

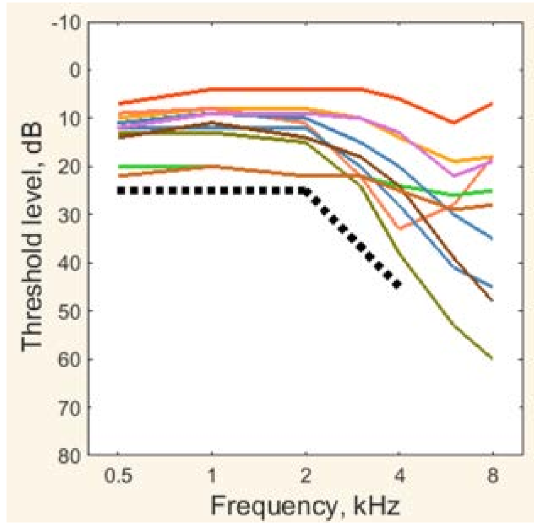


Figure 1. Audiometric configurations meeting the H-1 status. The dashed line represents the limit of the H-1 hearing status.

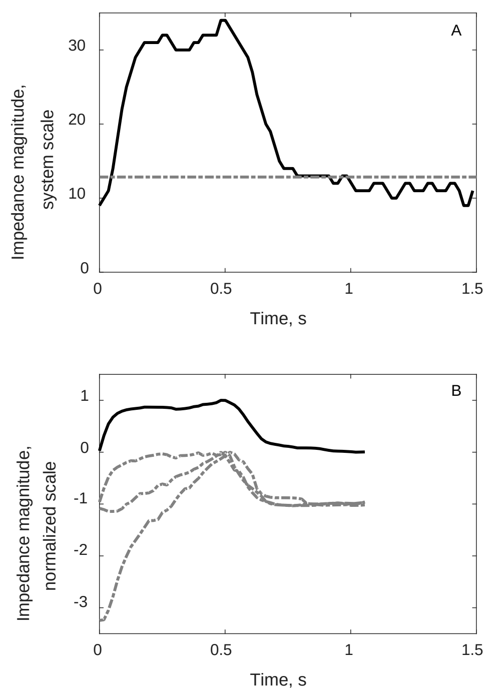


Figure 2. Example of acoustic reflex detection approach. Impedance as a function of time is represented in both panels. The upper panel (A) depicts the raw reflex trace in black. The criterion impedance for this trace (i.e., the impedance magnitude that is 1.96 standard deviations above the mean during the final 430 ms of the trace) is represented by the gray (dash-dot) line. The lower panel (B) represents the Kalman-filtered reflex trace in black, which is plotted on a normalized amplitude scale. The three prototype reflex traces are shown in gray and have been displaced downward on the plot for clarity.

	Prevalence	95 % confidence interval limits	
	%	Low	High
ALL (unweighted N = 15,106)			
Either	74.6	73.2	75.9
Frequentist	68.3	66.7	69.9
Bayesian / Kalman	58.5	57.1	59.9
Both	52.3	50.7	54.0
Ages 18-30 (unweighted N = 3280)			
Either	85.3	82.9	87.4
Frequentist	81.5	78.8	83.9
Bayesian / Kalman	72.2	69.7	74.6
Both	68.4	65.9	70.9
Ages 18-30, H1 (unweighted N = 3132)			
Either	86.9	84.8	88.7
Frequentist	83.4	81.1	85.5
Bayesian / Kalman	73.8	71.6	76.0
Both	70.4	68.0	72.6

Table 1. Prevalence of acoustic reflexes. Prevalence was estimated using both frequentist and Bayesian methods. The percentage of subjects that met either, each individually, and both criteria are shown along with the 95% CI for the entire sample, young adults subjects age 18-30, and those

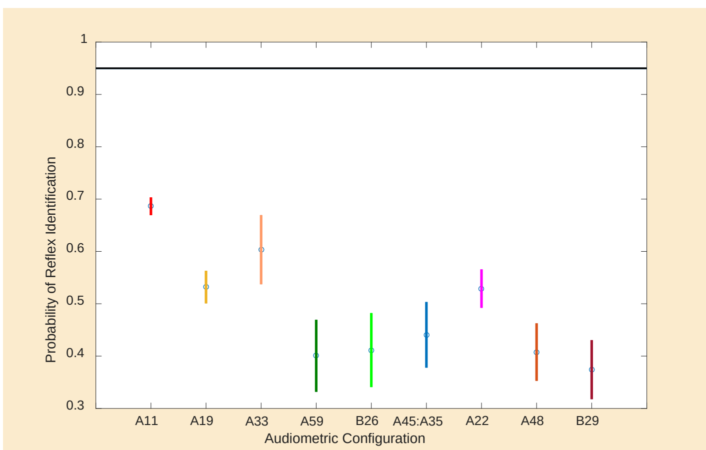


Figure 3. Prevalence of acoustic reflexes by audiometric configuration. Error bars represent the 95 % confidence interval for the proportion. Configurations can be linked by color to those displayed in Figure 3. The horizontal line at the 95 % reflex identification represents the level at which the lower confidence interval must be above to be considered pervasive in the population.

The required certainty of reflexive MEMC was not observed for any audiometric configuration meeting the H-1 hearing status, and prevalence was lower for other (worse) hearing status.

<u>Other achievements:</u> Nothing to report.

2. Determine whether reflexive MEMC are pervasive for multiple acoustic and non-acoustic stimuli.
3.

Major activities

The major activities during this period followed our proposed timeline. Our primary accomplishments during this reporting period included initiating pilot and routine data collection and further developing the procedures for data management and review on those tasks.

At the most recent examination of participant completion, which was 03 October 2016, a total of 210 participants had been scheduled (Figure 4). We planned for 40 pilot participants, but elected to enroll only 39 because we felt that the study protocol had undergone adequate testing and did not require further modification prior to enrolling routine participants. The remaining scheduled participants are classified as routine participants, the data from whom will contribute to answering the research questions.

To date, no scheduled participants have elected not to provide informed consent to participate, and one participant withdrew from the study for reasons unrelated to the protocol. Among the 178 participants who have completed the first protocol visit, 53 participants were found ineligible and dismissed from the study. The reasons for dismissal include inadequate hearing sensitivity, inadequate clinical acoustic reflexes, and self-reported physician-diagnosed concussion or brain injury. This corresponds to an approximate 30 % dismissal rate among participants providing informed consent to participate.

Among participants meeting the eligibility criteria, 112 had completed the second protocol visit, and 12 were awaiting their scheduled second visit.

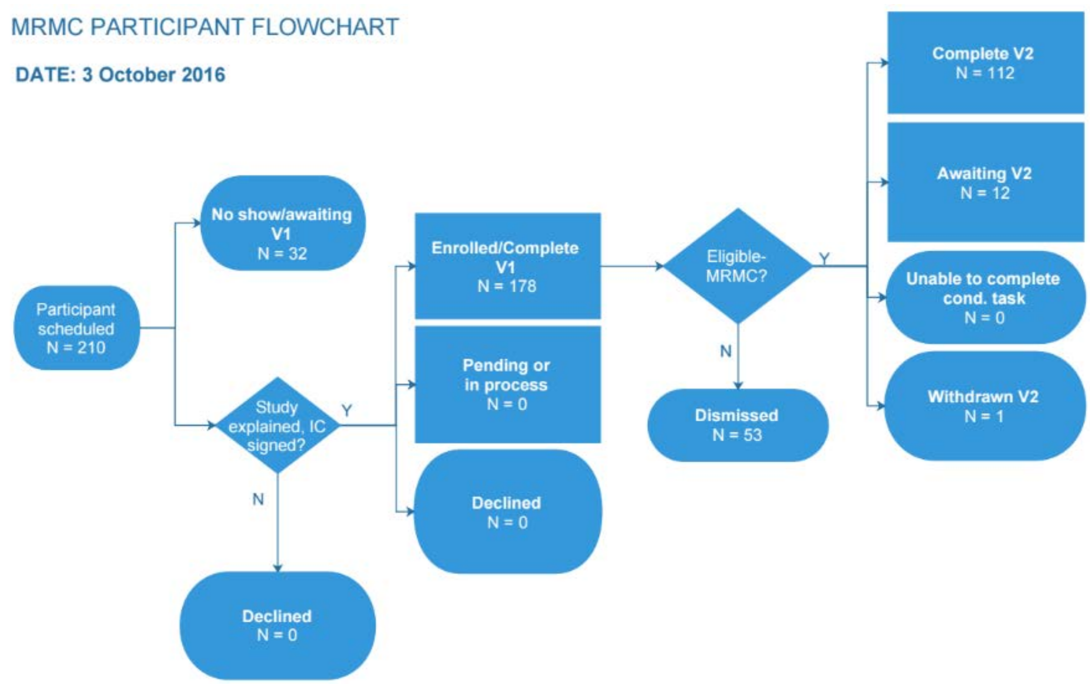


Figure 4. Participant enrollment flow chart. V1 represents the initial enrollment visit and V2 the data collection visit (including both reflexive and conditioned MEMC conditions addressing aims 2 and 3 in this report).

Data collection progress over time (Figure 5), which is determined by timestamps on computer files returned by the data collection procedures, indicates that our study procedures permit adequate participant completion rates to finish the study according to schedule. The initial visits from the bulk of the pilot participants were conducted between 19 OCT 2015 and 2 DEC 2015, and second visits were primarily completed between the dates of 27 OCT 2015 and 4 DEC 2015. We intentionally postponed enrollment and data collection to permit careful review of the procedures, data, and to avoid dividing participant appointments across the dates of university closure between semesters.

We have begun recruiting participants from sources expected to yield regular shooters. Recruitment of shooters has been slower than expected due to a high rate of hearing loss, and low interest in participation among this group. Recruitment from additional groups (including a ROTC program on the WMU campus) is underway, and we expect the number of enrolled shooters to increase dramatically in the next term.

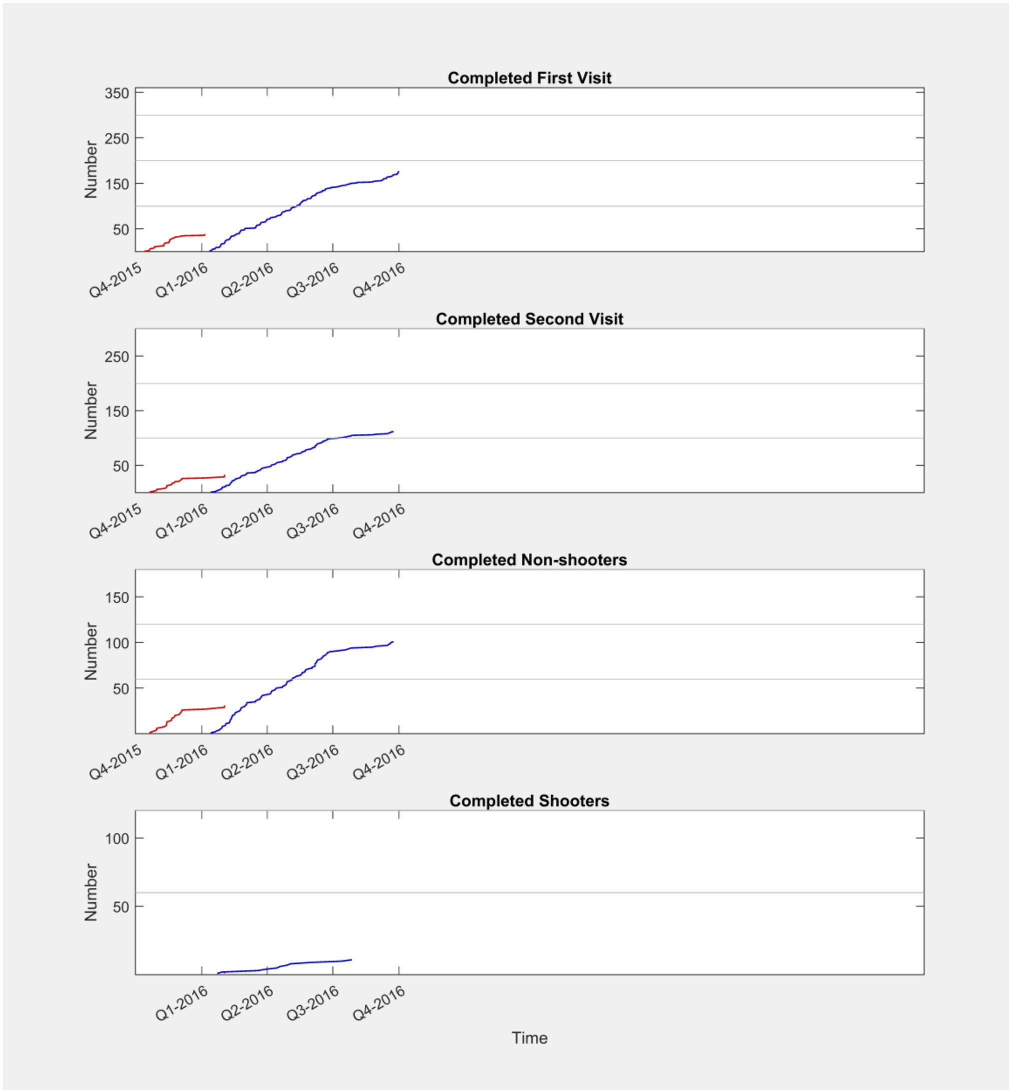


Figure 5. Cumulative numbers of participants in the laboratory study, by visit and participant group. Maximum vertical scale values are set to the anticipated numbers of participants of each type. The anticipated maximum number of participants for completed first visits was determined assuming a 20 % ineligibility rate.

<u>Specific objectives</u>

Our first objective associated with this task was to develop a reflexive MEMC study protocol, which was largely accomplished in the prior performance period. Briefly, the procedures used to determine candidacy include otoscopy, pure tone thresholds, tympanometry, wideband absorbance, clinical reflexive MEMC measurements, and verification of the integrity of the cranial nerves supplying the stapedius and tensor tympani muscles (CNVII and CNV, respectively). Experimental acoustic reflexive MEMC detection involves both acoustic and electromyographic (EMG) transducers. Surface EMG of multiple muscles sharing the neural supply of the stapedius and tensor tympani muscles is included in the reflexive MEMC protocol to help identify artifacts in the ear canal recordings associated with movement and to differentiate between contractions that are limited to the middle ear versus coordinated contractions across multiple muscles (e.g., a startle response). The procedures involved in the non-acoustic reflexive MEMC detection task involve the delivery of short-duration puffs of nitrogen gas to four areas of the face, light exposure, and tight eye closure.

Sample data

Data obtained in the laboratory study are examined as they are collected and subjected to initial review prior to the end of the participant visit. At the first visit, the initial review is used to make judgments regarding eligibility. At the second visit, data are compared with prior measurements to detect significant changes from baseline observations. Following initial review, data are subjected to detailed review to confirm initial judgments, identify procedural, hardware, or software errors. These review stages also include data reduction and summary procedures to facilitate subsequent integration and analysis.

Review of otoscopy includes examination of the video record for image quality and documentation that otoscopic landmarks were visualized. Pure tone threshold audiometry includes a general review of threshold results relative to inclusion criteria (Figures 6-7), along with a review of the time history of presentations and responses used to derive threshold (Figures 8-10).

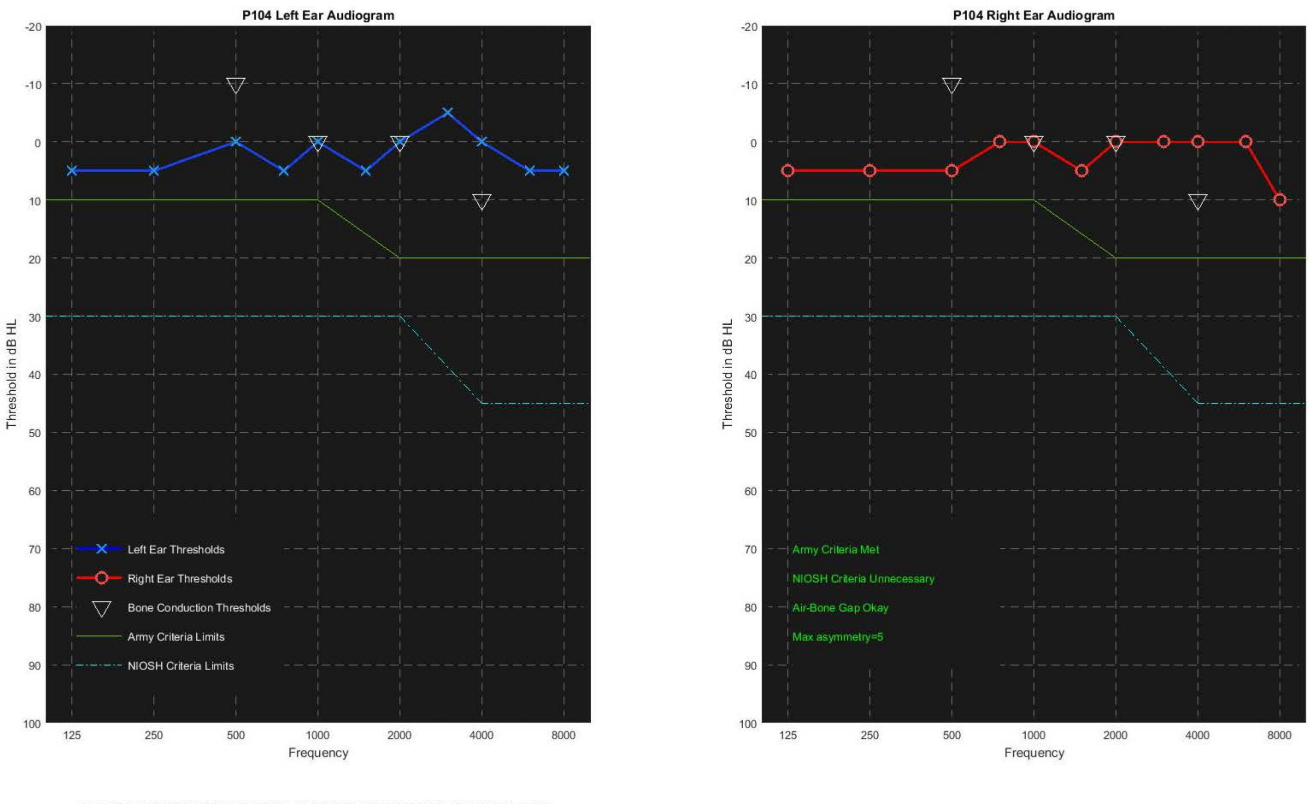


Figure 6. Example threshold audiogram of a pilot participant retained in the laboratory study.

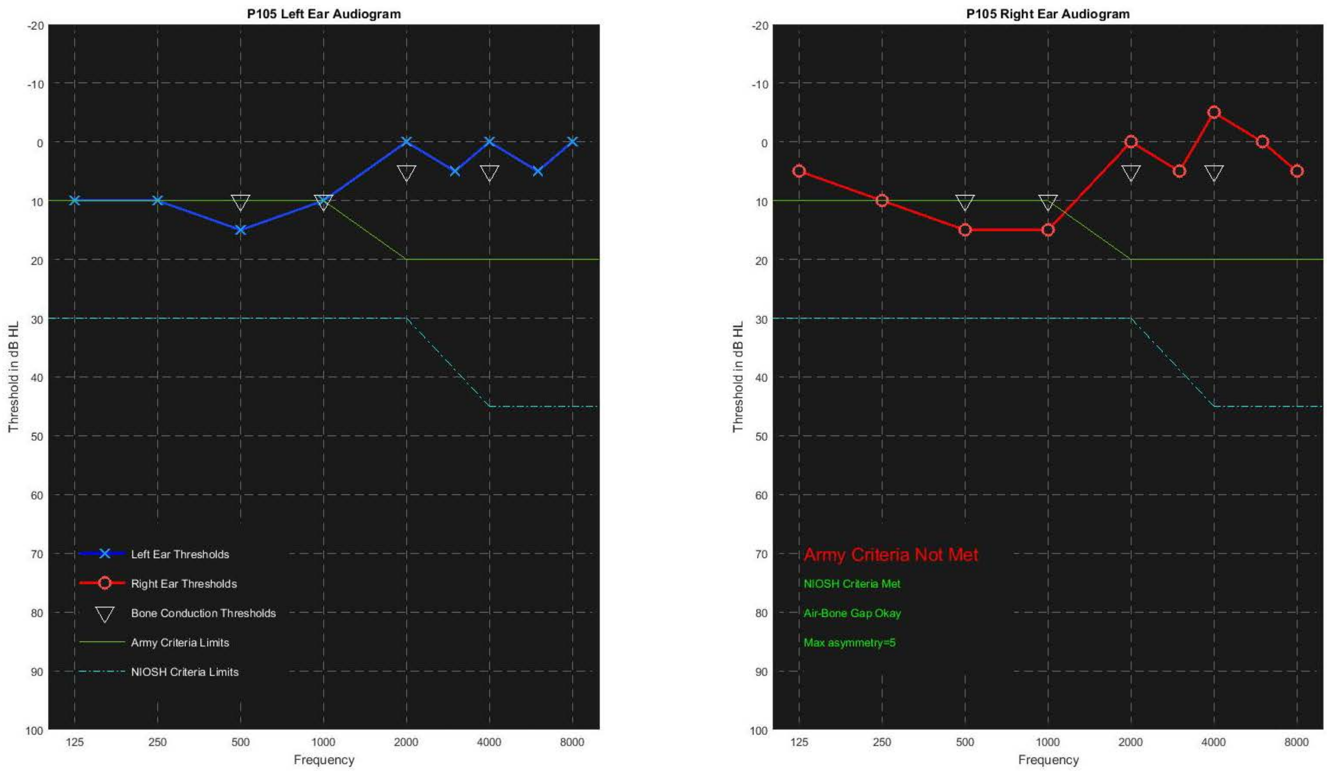


Figure 7. Example threshold audiogram of a pilot participant dismissed from the laboratory study.

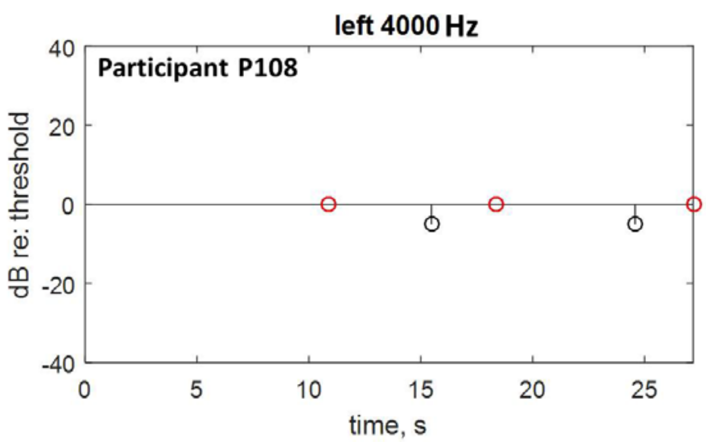


Figure 8. Threshold time history suggesting no difficulty obtaining threshold. The horizontal axis represents time, starting with the first stimulus presentation at that frequency. The vertical axis represents presentation levels relative to the threshold level returned by the run. Black symbols represent ascending presentations with no response. Red symbols represent ascending presentations that elicited a response from the participant.

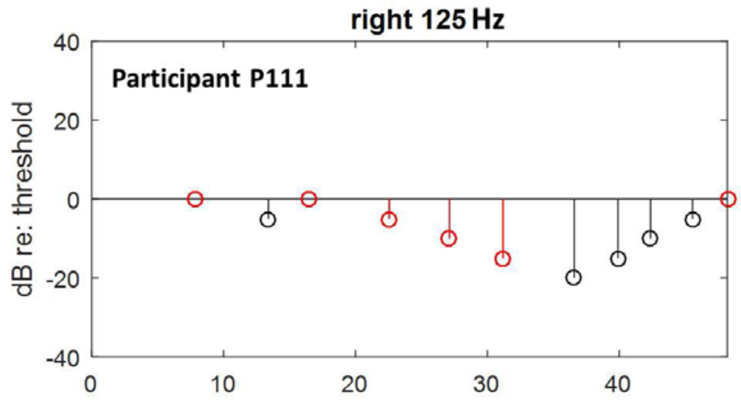


Figure 9. Threshold time history suggesting difficulty obtaining threshold. See Figure 8 caption for explanation of axes and symbols.

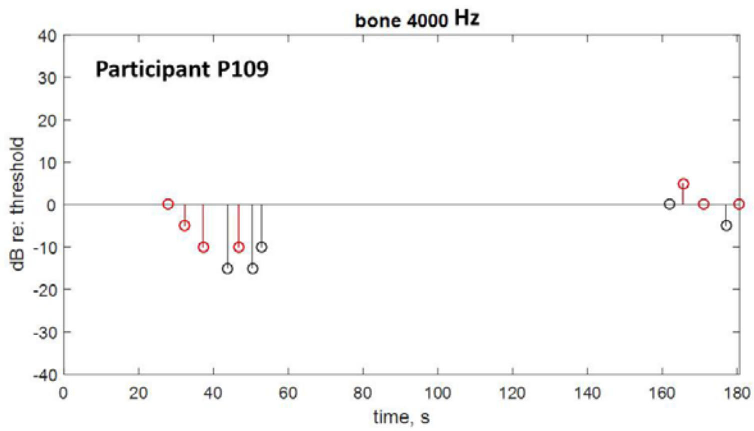


Figure 10. Threshold time history indicating retest. See Figure 8 caption for explanation of axes and symbols.

Similarly, middle ear and pupil conditioning measurements are reviewed for artifacts, errors, and hardware malfunctions prior to inclusion in the final dataset. For the experimental reflexive and conditioned tasks, data reviewers return binary indicators of artifacts or other data features suggesting that the data might be questionable (see Figures 11-13 for examples). These binary indicators can be crosstabulated across levels of review within a task, and permit sensitivity analyses in the evaluations of primary outcome. For example, they permit the evaluation of whether traces containing artifacts might have influenced decisions about the presence or absence of MEMC.

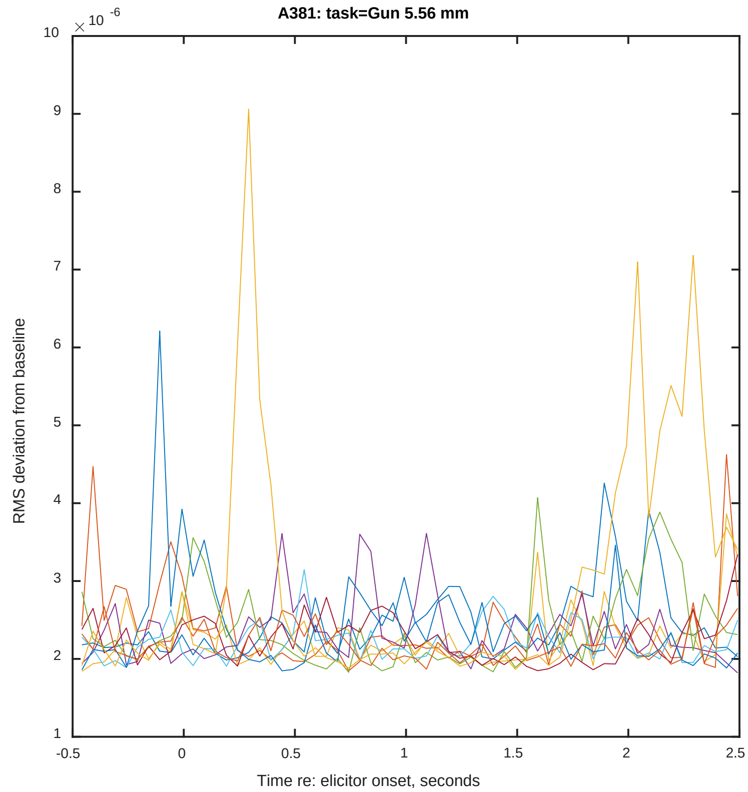


Figure 11. Example of outlier detection. Individual traces represent RMS deviations from baseline during the time interval surrounding the elicitor. Binary indicators of outliers are used to identify atypical deviation histories for further examination and potential censoring in subsequent analyses.

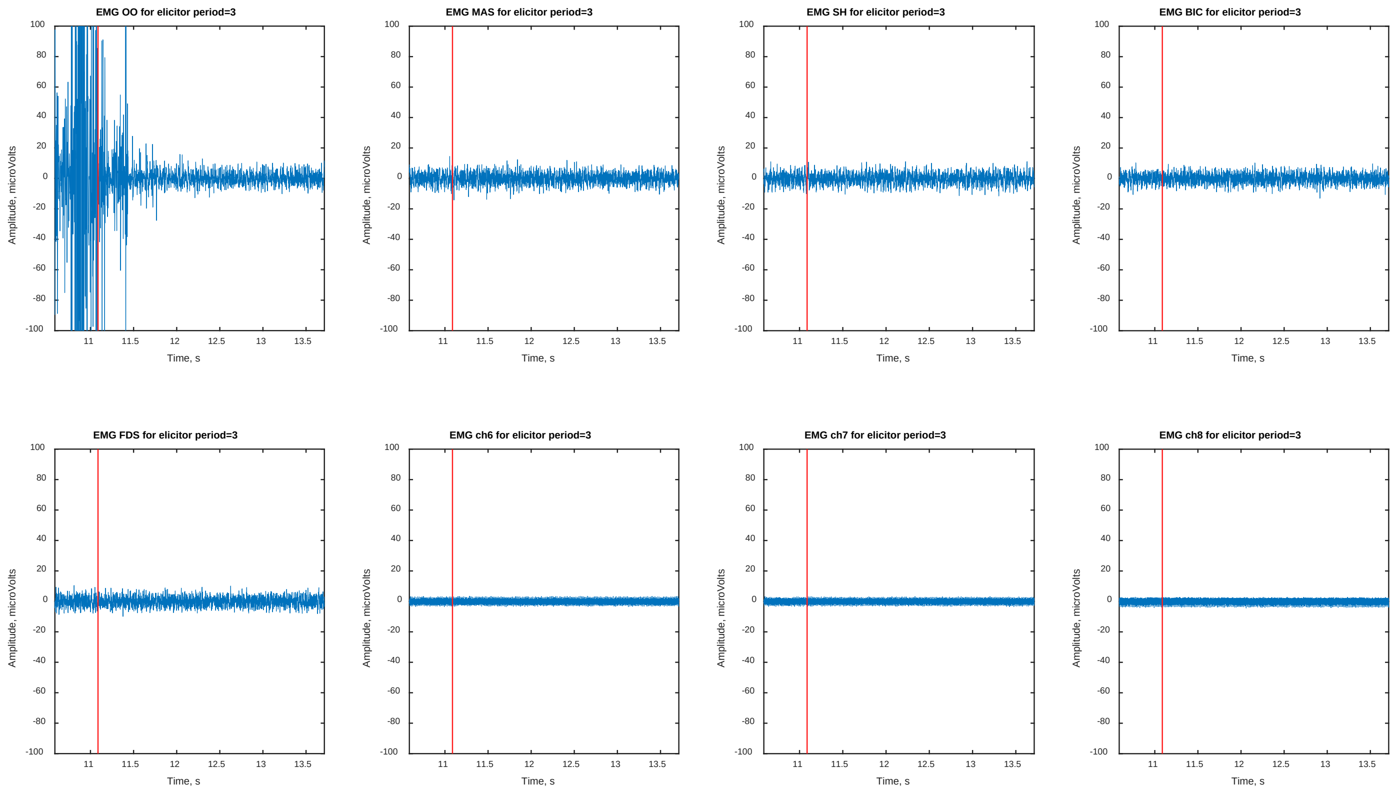


Figure 12. Review of EMG activity during elicitor periods. Each plot represents a separate channel for the EMG system. The activity of the *orbicularis oculi (OO)*, *masseter (MAS), suprahyoid complex (SH),* and *biceps (BIC)* muscles are represented in the upper row. The activity of the *flexor digitorum superficialis (FDS)* muscle is represented in the first column of the lower row. The remaining plots are used to identify system noise and/or can be used as spare channels in the event of equipment malfunction. In this example, activity of the musculature surrounding the eye occurred in the moments prior to the elicitor onset. Only the OO channel would be flagged in this example. Data reviewers use binary indicators of EMG activity, which permits crosstabulation with binary outlier identification (Figure 11) and possible censoring of trials in subsequent analyses.

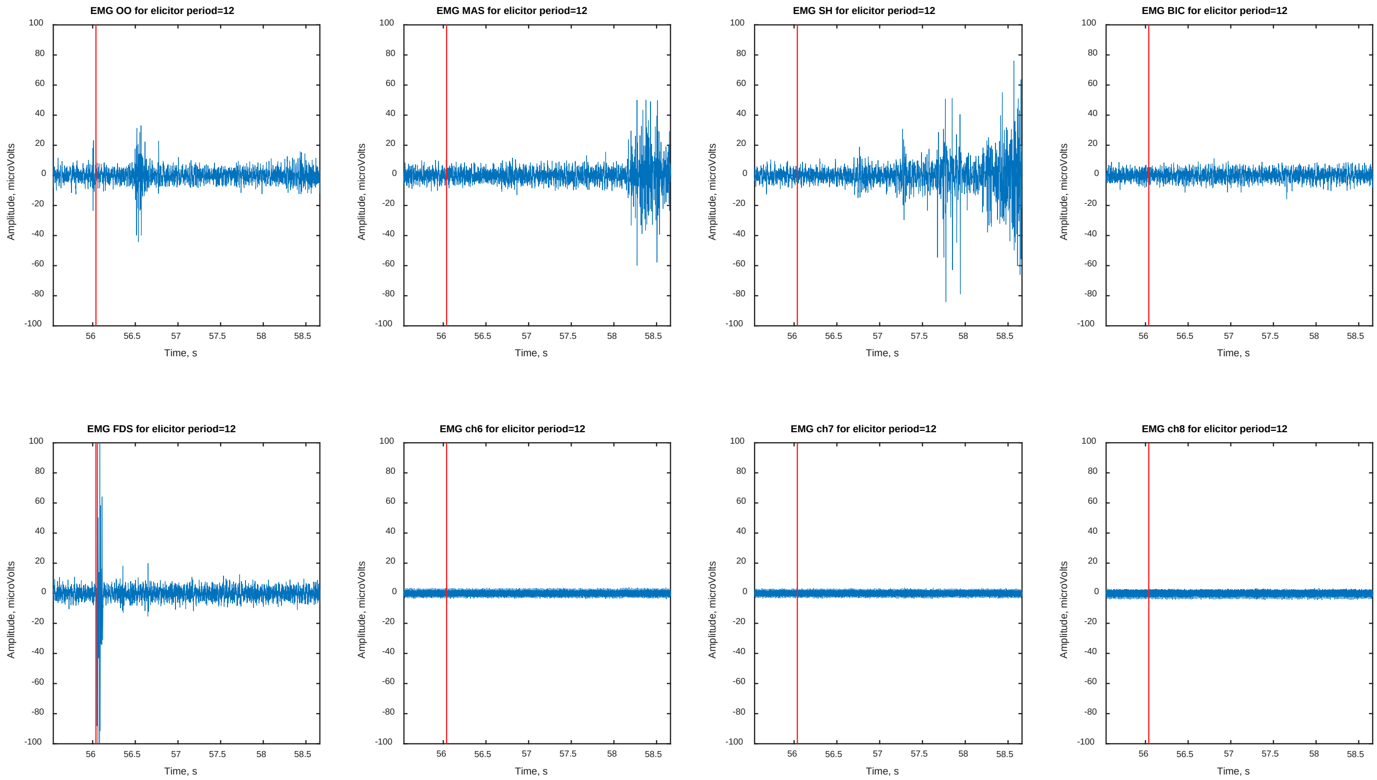


Figure 13. Additional review of EMG activity during elicitor periods. Figure layout is similar to Figure 12. In this example, activity from OO (probably an eyeblink) occurred just before the elicitor onset and approximately 0.5 s afterward, activity in the FDS was noted just after elicitor onset, and the MAS and SH signals became active (probably associated with swallowing) during the final 1.6 s of the elicitor window.

Experimental measures of MEMC are based on changes in the amount of sound developed in the ear canal in response to an acoustic click stimulus. The MEMC is defined in terms of repeatable and sustained deviations from the baseline, as is illustrated in Figure 14. Prior to quantitative assessment of MEMC activity, data reviewers use binary indicators to judge the presence/absence of an MEMC.

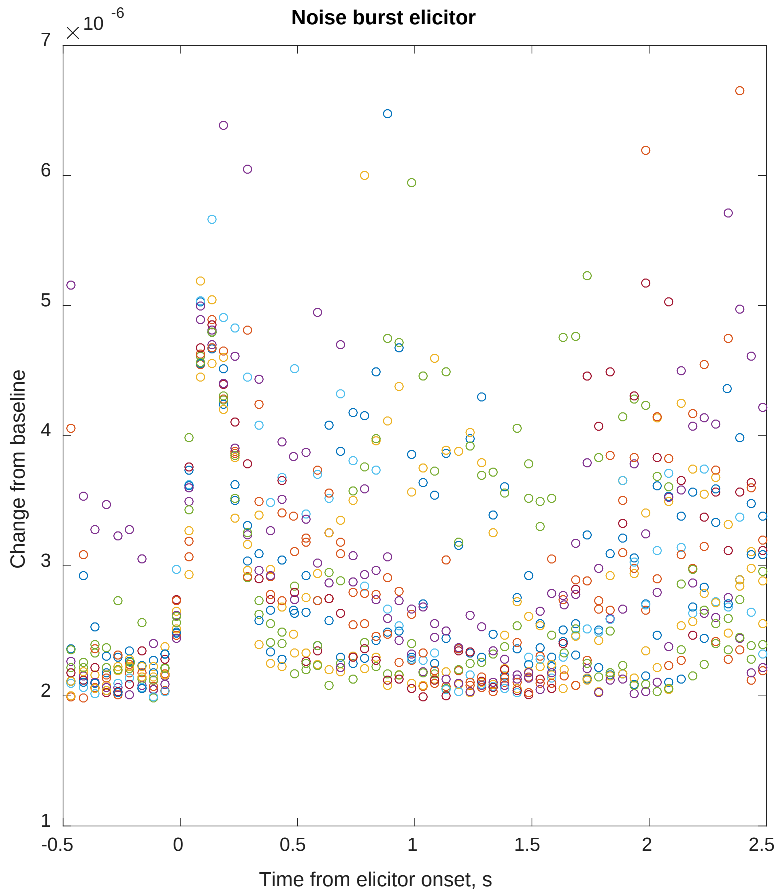


Figure 14. Example of reflexive MEMC in response to a noise burst. The horizontal axis represents time from the onset of the noise burst stimulus. The vertical axis represents the change in RMS amplitude of the signal developed in the ear canal, relative to baseline observations obtained prior to the onset of each elicitor. The symbols represent changes in RMS amplitude, observed in 50 ms intervals. The noise burst stimulus was presented 12 times, so there are 12 symbols in each interval. The MEMC is indicated by the systematic change in baseline between 0 and approximately 0.35 seconds.

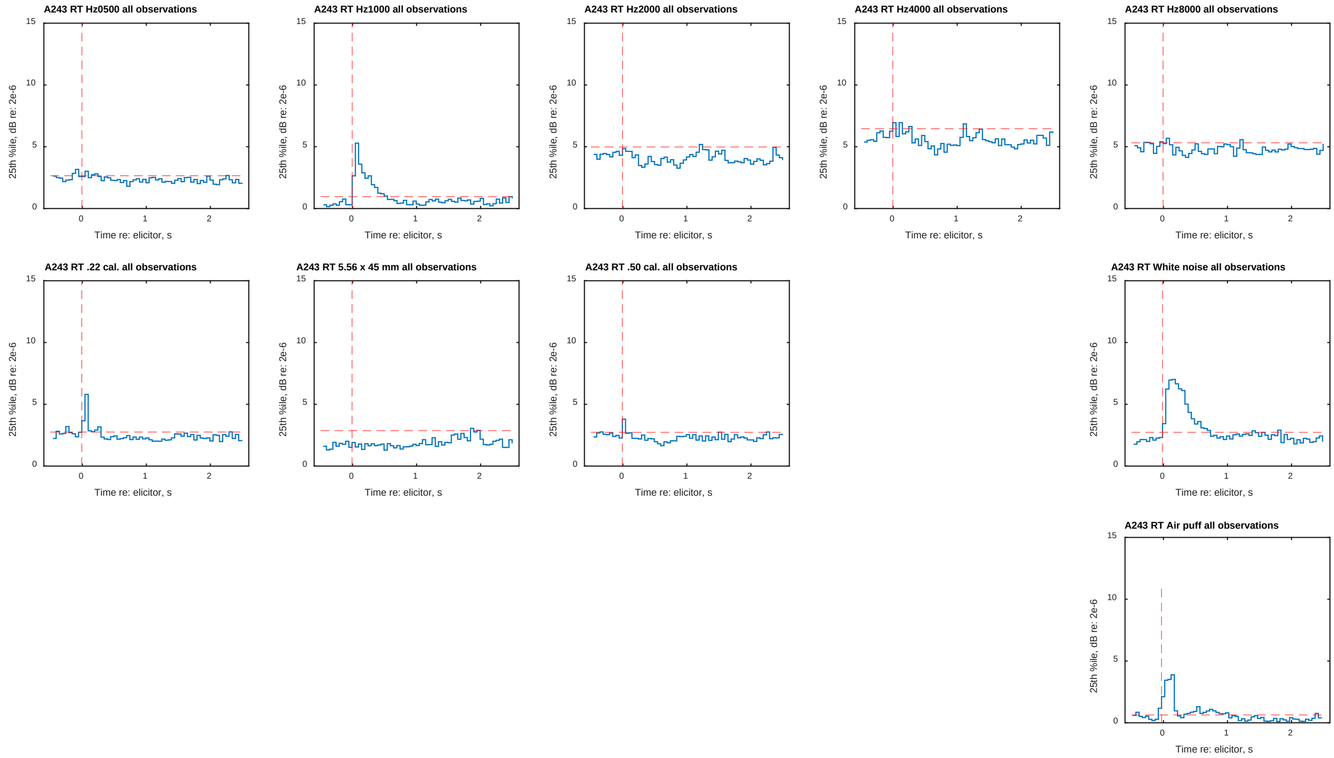


Figure 15. Summary of MEMC activity across reflexive tasks. Each plot represents a separate reflexive task, ranging from tones, recorded gunshots, white noise, eye closure (not shown) and air puffs. Plotted values are the 25th percentiles of the distributions in each 50 ms click interval. For each elicitor, reviewers indicate whether substantial stimulus-linked activity is present. Two reference lines facilitate the reviewer's task. The vertical dashed line represents elicitor onset. The horizontal dashed line represents the upper limit of the 95 % confidence interval for the final segment of the trace. In this example, marked activity is shown for the 1000 Hz, .22 caliber, .50 caliber, white noise, and air puff elicitors.

In addition to ongoing review of data during acquisition, data obtained in the lab-based MEMC tasks are subject to review in terms of the reliability of average baseline click waveforms acquired in the ear canal, consistency of individual click waveforms acquired around the time of the elicitor (i.e., between 0.5 seconds before and 2.5 seconds after elicitor onset), difference clicks (i.e., subtraction of the most recent baseline average click from individual clicks acquired around the time of the elicitor), changes in click RMS around the time of each elicitor (Figure 15), and summary statistics of changes in click RMS.

The laboratory protocol includes the necessary information to detect changes in hearing sensitivity that would be consistent with a noise-induced temporary threshold shift (TTS). To date, no individual participant has shown threshold differences indicating a TTS, and summary data across participants completing the second lab visit show no indication of a TTS trend. Mean changes across frequencies ranged between -1.6 dB and + 0.4 dB (median value = 0 dB in each ear at each stimulus frequency) which is well within the expected range of test-retest differences for pure tone stimuli and Sennheiser HDA200 earphones. Thus, we report no evidence of TTS among study participants.

The second and third objectives were to apply the protocol in laboratory and field settings. Pilot testing of the reflexive protocol in lab settings was initiated near the end of this study period and will be followed by the collection of study data. Application of the protocol in field settings is not scheduled until 2017.

The final objective was the analysis and dissemination of reflexive findings. Preliminary analysis routines have been developed and will be applied once sufficient study data are obtained.

<u>Significant results:</u> We have no significant results to report because we are in an early stage of data analysis.

<u>Other achievements:</u> Nothing to report.

4. Determine whether conditioned MEMC are pervasive, in either laboratory or field settings, and if so, identify differences between reflexive and conditioned MEMC.

Major activities

The major activities on this task during this period followed our proposed timeline and were devoted to the development and testing of the conditioned tasks.

Specific objectives

Our first objective associated with this task was to develop a reflexive MEMC study protocol, which was largely accomplished in the prior performance period. Briefly, this protocol involves execution of each of five conditioned tasks, and presentation of probe clicks with concurrent ear canal recordings to identify MEMC during the trial. The first conditioned task (Attended Auditory, AA) requires the subject to identify a gap (conditioned stimulus) in a series of beeps, while a white noise unconditioned stimulus, which will produce a MEMC, follows the gap. The second conditioned task (Attended Light, AL) involves the use of a change in an image on a video monitor as the conditioned stimulus, while the same white noise unconditioned stimulus will be used. The third conditioned task (Unattended Auditory, UA) is identical to the AA task, except that instead of asking the participant to press a response button when they detect the gap, they are asked to track a target on the video monitor using a toy gun mounted on a stand. The fourth conditioned task (Simulated Trigger, ST) uses the same toy gun as the UA task; however, in this task, only the MEMC probe clicks will be presented. The fifth conditioned task (Dry Fire, DF) is identical to the ST task, with the exception that a disabled gun is used instead of a toy gun.

Sample data

Data for the Conditioned MEMC portion of the study are obtained in the laboratory on the second day of testing (V2) along with the Reflexive MEMC data, and similarly examined as they are collected and subjected to initial review prior to the end of the participant visit. Following initial review, data are subjected to detailed review to confirm initial judgments, identify procedural, hardware, or software errors. These review stages also include data reduction and summary procedures to facilitate subsequent integration and analysis.

Figure 16 shows a representative DF MEMC plot from a single subject. Time=0 represents the approximate time of arrival of the DF hammer impact at the participant's ear, based on the approximate path length difference between the hammer and ear versus the hammer and field microphone. The vertical axis is the RMS difference from baseline as a function of time. Each step function represents one trigger pull. The thick dashed reference line is placed at time = -0.05.

We evaluate the change in the energy developed in the ear canal in 50 ms intervals because the click interval is 50 ms, and this leads to the use of a stairs plot. Thus, if the energy in the ear canal increases at any point during the 50 ms interval, the stair for that entire interval is increased. The MEMC detection paradigm is based on changes in acoustic energy in the ear canal, whether it is because of a change in middle ear impedance or because of a change in the noise (i.e., the hammer impact) infiltrating the ER-10x probe. So some stairs appear to go up at -0.050 sec, but that is not surprising. This is more than likely the hammer impact noise having come through the ER10x probe at the tail end of the prior 50 ms interval.

Anticipatory MEMC would be represented by a change in the energy developed in the ear canal prior to the arrival of the impact noise. Thus, one would expect to observe a reliable change from baseline on the left side of the dashed line. It is reasonable to expect that the ear canal response would be time-linked with (and possibly precede) the increase in trigger force. The interval from about -0.2 to -0.1 seconds would be a reasonable time to see this, which we have not yet observed. For this subject, there are a couple of trigger pulls that show a potential change in the baseline prior to the dashed line, but they are not consistent across trigger pulls, and they return toward baseline prior to the onset of the elicitor and therefore are unlikely to provide any protection.

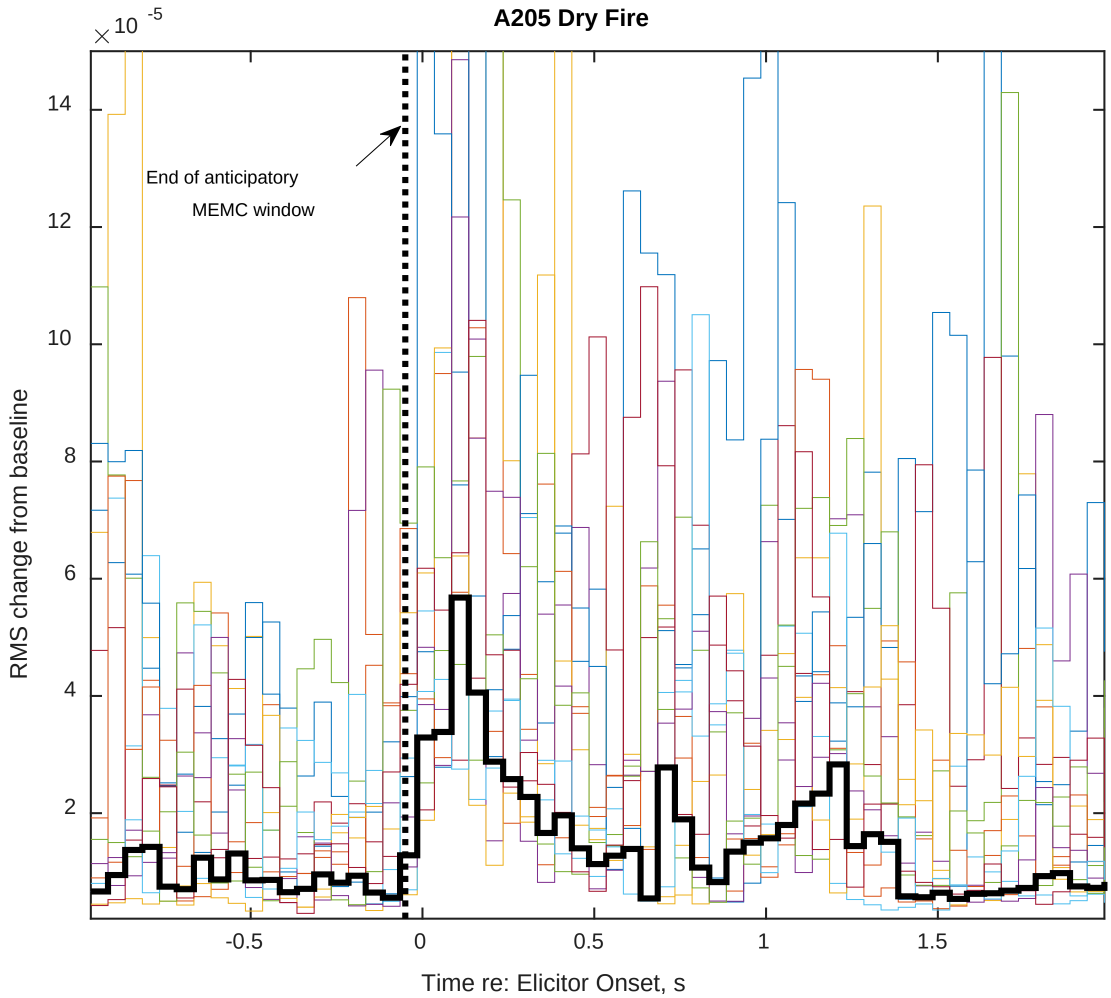


Figure 16. Example of conditioned MEMC outcome for one participant assigned to the *dry fire (DF)* task. Thin non-black step functions represent individual trials (i.e., trigger pulls on the disabled gun) and the thick black step function represents the 25th percentile of the distribution within each 50 ms time interval. The vertical dotted line represents the earliest onset of the click interval associated with any trial. The deflection of the 25th percentile after the vertical dotted line cannot be interpreted easily because it could represent a reflexive MEMC, infiltration of the impact noise from the disabled gun hammer, or a combination of both. An upward deflection of the 25th percentile prior to the end of the anticipatory MEMC window would be consistent with an anticipatory MEMC. Evidence of an anticipatory MEMC was not seen in this example.

The second and third objectives include application of the protocol in laboratory to a field settings at USAARL. Development of the experimental apparatus and pilot testing of the protocol in the laboratory setting was initiated near the end of this study period and will be followed by the collection of study data. Testing of the protocol in a field settings is not scheduled until 2017.

The final objective was the analysis and dissemination of reflexive findings. Preliminary analysis routines have been developed and will be applied once sufficient study data are obtained.

<u>Significant results:</u> We have no significant results to report because data collection is not yet complete.

<u>Other achievements:</u> The principal achievement associated with this objective was collection of the majority of data required from the non-shooter population.

What opportunities for training and professional development has the project provided?

Nothing to report.

How were the results disseminated to communities of interest?

Presentations were made at: USAMRMC In-Progress Review meeting; Japan-US Forum on Blast Injury 2016 (JUFBI-2016); Scientific and Technology Meeting of the American Auditory Society; Scientific and Technology Meeting of the American Auditory Society. Scottsdale, AZ; National Hearing Conservation Association Annual Meeting; National Hearing Conservation Association Annual Meeting;

What do you plan to do during the next reporting period to accomplish the goals?

During the next reporting period, our efforts will focus on completing the laboratory data collection protocol with human subjects, modifying the protocol for use in field studies, and publishing manuscripts summarizing our results on laboratory reflexive and conditioned stimulus MEMC data collection.

Impact

What was the impact on the development of the principal discipline(s) of the project?

In the field of hearing science, the methods developed for this study enable the assessment of MEMC for a wide range of stimuli, and ultimately this project can provide information about the best way to account for MEMC in damage-risk criteria for impulsive noises.

What was the impact on other disciplines?

Nothing to report.

What was the impact on technology transfer?

Nothing to report.

What was the impact on society beyond science and technology?

The MEMC has been assumed to have a protective role in many damage-risk criteria for impulsive sounds. Some damage-risk criteria have presumed that a listener who knows of an imminent impulse will produce anticipatory protective MEMC via classical conditioning. There is a weak evidentiary basis for a protective role of MEMC for such brief sounds, and the evidentiary basis for an anticipatory MEMC is nearly non-existent. The current project is likely to inform the development and application of damage-risk criteria and health hazard evaluations by policymakers. The consequent improvements in the accuracy of damage risk criteria will benefit warfighters and other personnel exposed to impulsive sounds in the line of their duty and occupation. In addition, these criteria could inform the evaluation of the hazard of impulsive noise for firearm users.

Changes/Problems

Changes in approach and reasons for change

Nothing to report.

Actual or anticipated problems or delays and actions or plans to resolve them

There was a delay in the manufacture of some key hardware (i.e., the ER-10x system) because it is a new system. However, this system has been delivered and is operating well.

Changes that had a significant impact on expenditures

There have been delays in hiring staff. At the Western Michigan University site, the delays were tied to the delay in the manufacture of the ER-10x system. The additional personnel were not needed until all hardware and software were in place. At the USAARL site, the delays with hiring staff have been related to the specialized skills required in that position and the reluctance of applications to move to Alabama.

Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

There have been no significant deviations, unexpected outcomes, or changes in approved protocols. Our efforts were approved by the Western Michigan University Institutional Review Board on 11 November 2014 for the reflexive MEMC prevalence study and designated as research *not involving human subjects* by the MRMC HRPO on 15 February 2015. The laboratory study was approved by the Western Michigan University Institutional Review Board on 14 April 2015 and approved by the MRMC HRPO on 8 May 2015.

<u>Products</u>:

Publications, conference papers, and presentations

Journal publications

1. Flamme GA, Deiters KK, Tasko SM, Ahroon WA (under review). Acoustic reflexes are common but not pervasive: Evidence from the National Health and Nutrition Examination Survey, 1999-2012. *International Journal of Audiology*.

Conference papers, and presentations

1. Ahroon, W. A. (2016b). *Concerns Regarding Using MIL-STD-1474E "Noise Limits" As a Health Hazard Assessment Tool*. Paper presented at the Office of Naval Research Noise-Induced Hearing Loss Program Review, Memphis, TN.
2. Flamme, G. A., Ahroon, W. A., Tasko, S. M., Deiters, K. K., & Murphy, W. J. (2016a). *Effects of Acoustic Impulses on the Middle Ear*. Paper presented at the Office of Naval Research Noise-Induced Hearing Loss Program Review, Fort Detrick, MD.
3. Flamme, G. A., Ahroon, W. A., Tasko, S. M., Deiters, K. K., & Murphy, W. J. (2016b). *Effects of Acoustic Impulses on the Middle Ear*. Paper presented at the U.S. Army Medical Research and Materiel Command, Military Operational Medicine Hearing Research In Progress Review, Fort Detrick, MD.
4. Flamme, G. A., Deiters, K. K., Tasko, S. M., & Ahroon, W. A. (2016). *Prevalence of Acoustic Reflexes in the US: Implications for Damage-Risk Criteria for Impulsive Noise*. Paper presented at the Japan-US Forum on Blast Injury 2016, Tokyo, Japan.
5. Flamme, G. A., Tasko, S. M., Deiters, K. K., & Ahroon, W. A. (2015). *Assessing acoustic reflexes for impulsive sounds*. Paper presented at the 170th Meeting of the Acoustical Society of America, Jacksonville, FL.
6. Flamme, G. A., Tasko, S. M., Deiters, K. K., & Ahroon, W. A. (2016a). *Acoustic Reflex Prevalence in the United States*. Paper presented at the Annual Meeting of the American Audiology Society, Scottsdale, AZ.
7. Flamme, G. A., Tasko, S. M., Deiters, K. K., & Ahroon, W. A. (2016a). *Are acoustic reflexes sufficiently pervasive for inclusion in Damage-Risk Criteria for Impulsive Noise?* Paper presented at the 37th Annual Hearing Conservation Conference, San Diego, CA.

8. Flamme, G. A., Tasko, S. M., Deiters, K. K., & Ahroon, W. A. (2016b). *Are Acoustic Reflexes Sufficiently Pervasive for* Inclusion in Damage-risk Criteria for Impulsive Noise? Paper presented at the 2016 Military Health System Research Symposium, Kissimmee, FL.
9. Flamme, G. A., Tasko, S. M., Deiters, K. K., & Ahroon, W. A. (2016b). Middle Ear Muscle Contraction Assessment for Impulsive Sounds. Paper presented at the Annual Meeting of the American Audiology Society, Scottsdale, AZ.
10. Flamme, G. A., Tasko, S. M., Deiters, K. K., & Ahroon, W. A. (2016c). Reflexive anticipatory middle ear muscle contractions for impulsive sounds. Paper presented at the 37th Annual Hearing Conservation Conference of the National Hearing Conservation Association, San Diego, CA.
11. Stehouwer, T. J., Flamme, G. A., Tasko, S. M., Deiters, K. K., & Ahroon, W. A. (2016). *Measurement of pupil contractions in response to auditory stimuli*. Paper presented at the 37th Annual Hearing Conservation Conference of the National Hearing Conservation Association, San Diego, CA.

Books or other non-periodical, one-time publications

Nothing to report.

Other publications, conference papers, and presentations.

Website(s) or other Internet site(s)

Nothing to report.

Technologies or techniques

Nothing to report.

Inventions, patent applications, and/or licenses

Nothing to report.

Other Products Nothing to report.

Participants & Other Collaborating Organizations

What individuals have worked on the project?

Name:	William A. Ahroon, Ph.D.
Project Role:	Principal Investigator (USAARL)
Nearest person month worked:	3 (Calendar)
Contribution to Project:	Dr. Ahroon is a Research Psychologist in the Acoustics Branch of the U.S. Army Aeromedical Research Laboratory (USAARL). As the PI for this project, he will be responsible for scientific and programmatic oversight of the project. Specifically, he will guide the protocol through the IRB and other regulatory reviews in implementing the protocol at USAARL, train and supervise research personnel, and facilitate team meetings.
Name:	Nathaniel T. Greene, Ph.D.
Project Role:	Co-Investigator (USAARL)

Nearest person month worked:	5 (Calendar)
Contribution to Project:	Dr. Greene is a Research Audiologist employed by the Geneva Foundation, working under the supervision of Dr. Ahroon in the Acoustics Branch of the U.S. Army Aeromedical Research Laboratory (USAARL). Dr. Greene's duties are to develop, test, collect data, and prepare analytic routines for the USAARL portions of this study.

Name:	Gregory A. Flamme, Ph.D.
Project Role:	Principal Investigator (Western Michigan University)
Nearest person month worked:	0.125 (Academic) 0.67 (Summer)
Contribution to Project:	During year 1, Dr. Flamme's duties are to direct the analyses for the reflexive MEMC study, develop, test, and obtain pilot data for the reflexive and lab-based studies of reflexive and conditioned MEMC. During years 2 through 4, he will work on dissemination of prior results, direct the conduct of the lab-based MEMC studies, and coordinate with USAARL to obtain field study data that are maximally comparable across sites.

Name:	Stephen M. Tasko, Ph.D.
Project Role:	Co-Investigator (Western Michigan University)
Nearest person month worked:	0.125 (Academic) 0.67 (Summer)
Contribution to Project:	During year 1, Dr. Tasko's duties are to develop, test, obtain pilot data, and prepare analytic routines for the EMG-based measurements obtained in this study. During years 2 and 3, he will manage the EMG-based measurements, perform ongoing quality assurance tasks, and conduct analyses on these data. During year 4, he will conduct analyses on the WMU EMG measures and work on dissemination of study data.

Name:	Kristy K. Deiters, Au.D.
Project Role:	Co-Investigator (Western Michigan University)
Nearest person month worked:	2.4 (Calendar)
Contribution to Project:	Dr. Deiters will be the project coordinator during all years of the project, focusing on participant recruitment, day-to-day operations, and coordinating efforts between WMU and USAARL. During years 2 through 4, she will also be responsible for data management, quality assurance, descriptive analyses, preparing data sets for inferential analyses, and dissemination.

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

Nathaniel T. Greene, Ph.D. has been added to the project.

What other organizations were involved as partners?

None

Special Reporting Requirements

Quad Chart: Attached

Appendices

None.

"Effects of Acoustic Impulses on the Middle Ear"

Log Number: 13063028

Award Number: W81XWH-14-2-0140

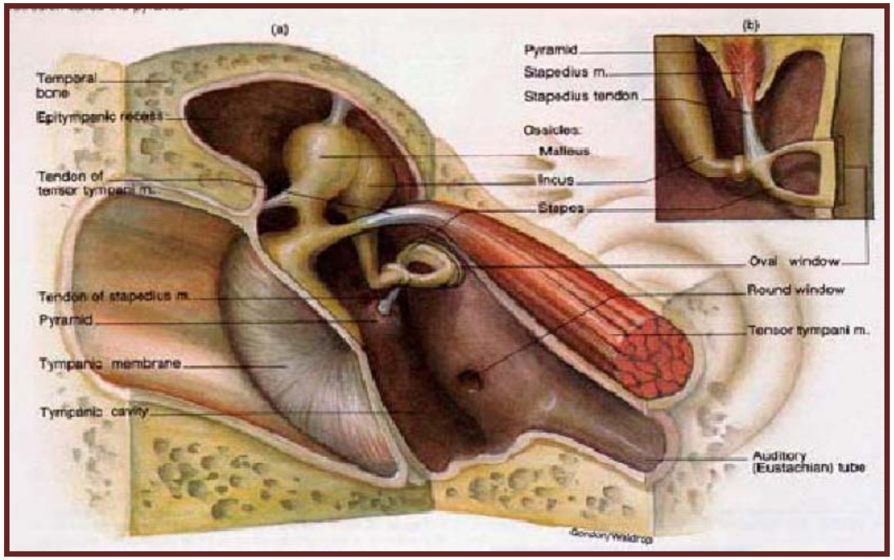
PI: William A. Ahroon, Ph.D. **Org:** The Geneva Foundation/U.S. Army Aeromedical Research Laboratory **Award Amount:** $3,081,623

Study/Product Aim(s)

- Fully document the effects of acoustic impulses on the middle ear and on middle-ear muscle contractions (MEMC)
- Determine the prevalence of the MEMC as a function of hearing sensitivity and demographic factors.
- Determine whether reflexive MEMC are pervasive among normal-hearing listeners.
- Determine whether classically-conditioned MEMC are pervasive among normal-hearing listeners.
- Determine the validity of the middle-ear assumptions of the Auditory Hazard Assessment Algorithm for the Human Ear (AHAAH)

Approach

The response of the middle ear to acoustic impulses will be measured using Wide Band Absorbance (WBA) alone and in classical conditioning paradigms.



Timeline and Cost

Activities CY	14	15	16	17	18
NHANES prevalence study					
Characterize MEMC using WBA					
MEMC classical conditioning test					
Operational evaluation of MEMC					
Estimated Budget ($3,081,623)	275.4K	804.6K	776.8K	767.3K	457.5K

Updated: 20 OCT 2016

Goals/Milestones

CY15 Goal – MEMC Prevalence

✓ Develop MEMC detection algorithm on NHNES impedance traces

✓ Determine the prevalence of the acoustic reflex from the NHANES data base

CY16 Goals – Wide-band Absorbance Methods

✓ Validate MEMCs using Wide-Band Absorbance

CY17 Goal – MEMC Classical Conditioning

☐ Determine form and prevalence of MEMC conditioned response

CY18 Goal – Operational Demonstration

☐ Sniper-spotter lab & field test of AHAAH middle-ear assumptions

Comments/Challenges/Issues/Concerns

- None

Budget Expenditure as of 9.30.16

Projected Expenditure: $2,395,381

Actual Expenditure: $897,720